EXHIBIT C

HEALTH CONSULTATION

GAVIN POWER PLANT
CHESHIRE, GALLIA COUNTY, OHIO

BACKGROUND AND STATEMENT OF ISSUES

The U.S. Environmental Protection Agency (EPA), Region V, has requested the Agency for Toxic Substances and Disease Registry (ATSDR) to determine if a public health hazard exists for Cheshire, Ohio, community members residing near the Gavin Power Plant. EPA has provided ATSDR with ambient air sulfur dioxide and sulfuric acid data and community health complaints (US EPA 2001a). A recent (May 2001) installation of air pollution controls has resulted in frequent reports from community members about visible plumes at ground level followed by respiratory problems and eye, nose, and throat irritation.

The facility, operated by American Electric Power (AEP), is located in southeast Ohio (see Appendix A, map). The Village of Cheshire is along the Ohio River and adjacent to the power plant. The center of town is located within a one-half mile of the plant. Approximately 200 people live in Cheshire; 67% of the residents fall in the low-to-moderate income range (US EPA 2001a).

The Gavin Power Plant uses a high (3 to 4 percent) sulfur content coal as its fuel source. It burns an average of 5 million tons of coal annually. It is capable of producing 780 billion kilowatt hours of electricity per year from two generating units. Air pollution emission controls on each generating unit include an electrostatic precipitator to reduce particulate emission, and a lime flue gas desulfurization (FGD) system to reduce sulfur dioxide ($S0_2$) emissions (US EPA 2001a). The Toxic Release Inventory (TRI) emission data reported by the facility for the year 1999 show that large amounts of pollutants were released to the environment (see Table 1) (US EPA 2001a).

Table 1. Toxic Release Inventory (TRI) of emissions from the Gavin Power Plant for 1999

Contaminant	Pounds Released
Sulfuric acid aerosol	1,900,005*
Hydrochloric acid aerosol	390,005*
Hydrogen fluoride	56,005*
Nitrogen oxides (N0x)	103,874,000+

Sulfur dioxide (S02)	30,492,000+

* TRI reported emissions from AEP (file available from website; http://www.aep.com/Environmental/emissioncontrol/rtk/default.htm EXIT)

+ EPA Clean Air Market Program Database (http://www.epa.gov/airmarkets/emissions/index.html EXIT)

In May of 2001, the facility installed a selective catalytic reduction (SCR) system to reduce nitrogen oxides (NO_x) emissions. The SCR removes NO_x by injecting ammonia into the flue gas. The ammonia/flue gas mixture then passes through a vanadium pentoxide catalyst bed where the ammonia and NO_x react to form nitrogen and steam. Some of the SO_2 formed during the combustion of coal is further oxidized to SO_3 in the boiler. As the flue gas passes through the SCR catalyst bed, further oxidation of SO_2 to SO_3 occurs. Most of the sulfur trioxide reacts with water in the FGD system and forms a sulfuric acid mist. This mist is emitted from the stack and, because it is more dense than air, falls to the ground. In addition, SO_2, NO_x, particulate matter, and any unreacted ammonia are emitted from the stack (US EPA 2001a).

Since early July 2001, the EPA and the facility have been conducting ambient air monitoring and sampling. The Ohio EPA (OEPA) placed a permanent sulfur dioxide monitor at the Cheshire Village City Hall. On July 2 and 3, 2001, the EPA conducted ground-level air monitoring for sulfur dioxide. This mobile monitoring was conducted within a one-mile radius of the plant. Since June 30, 2001, AEP has been conducting air sampling within the visible plume for sulfur dioxide, using a mobile monitoring unit. AEP has also conducted some limited sampling for sulfuric acid. The sources of air monitoring data provided to ATSDR for this consultation are summarized in Table 2.

Currently, the EPA and OEPA are implementing a year-long sampling effort to better characterize the ambient air quality in and around Cheshire Village. Three schools in and near Cheshire will have sampling stations for particulate matter (PM10 and TSP) and metals. One of the 3 locations will also be sampled for PM 2.5.

Community Concerns

Complaints from the community have occurred over the past several years. However, reports of more severe health effects have appeared since the beginning of summer and are attributed by residents to a more intense plume that frequently touches the ground in Cheshire. ATSDR was provided with several letters and diaries written by community members in early summer 2001. Residents reported seeing visible plumes frequently in and around the town. Some residents were unable to avoid contact with the plumes, and reported irritation of the eyes, nose, and throat; shortness of breath; and asthma-like symptoms. Several people indicated that after exposure to the plume, adults and children would experience red or raw throats and inflamed tonsils. Many people expressed health concerns for children in the area. They indicated that the area schools often do not allow children to go outside to play or exercise because of air quality. People with respiratory problems reported that their symptoms improved when they left the area (for example, during vacations), but symptoms returned when they came back home. There were also numerous comments about corrosion and discoloration of paint on cars and houses, and many references to the community being covered with soot and other materials (US EPA 2001a).

DISCUSSION

Environmental Data

The data provided to ATSDR by EPA Region V for this consultation is summarized in Table 2. It includes a large number of samples collected by EPA, OEPA, and AEP from late June until mid-October. The samples were taken at various locations and reported for various sampling times depending on the methods used.

Table 2: Summary of Cheshire Community Air Sampling Data Reviewed for this Consultation

	Dates	Sampling Time	Location	Data	Source
Sulfur Dioxide	July 2, 3	Continuous read-out	2 meters above ground level, readings from mobile unit at River Valley High School in OH and the dairy farm in WV	Appendix B, Figures 1 and 2	EPA
	Periodically from June 30 to August 17	Continuous read-out and 3-hour averages	Mobile unit, many locations sampled in area of visible plume in and around Cheshire	Appendix C, Figure 3 and Appendix D, Table 3	AEP
	August-September	1-hour and 24-hour averages	In Cheshire, top of City Hall 2-story bldg.	See text	OEPA
	August 19 to	5-minute averages	In Cheshire, top of City Hall	Appendix E, Figure 4	OEPA

	October 15		2-story bldg.		
Sulfuric acid	July 2 and July 18	0.5 to 9 hour sampling time	Unspecified locations	Table 4	AEP
	July 13 to August 11	Not reported	Various locations in and around Cheshire	Table 4	AEP

Sulfur Dioxide

EPA conducted continuous real-time air monitoring for sulfur dioxide at ground-level (2 meter sample height) on July 2 and 3, 2001. During this plume touch-down event, levels of sulfur dioxide were recorded as high as 120.6 ppb at River Valley High School and as high as 163 ppb at a dairy farm in West Virginia. Appendix B, Figures 1 and 2, provides a visual display of sulfur dioxide levels over time at these two locations. The figures show the episodic nature of sulfur dioxide in air, with sulfur dioxide levels rising and falling throughout the day. While monitoring at the River Valley High School, the sulfur dioxide levels exceeded 10 ppb for more than eight hours--from 2:10 pm (when monitoring began) until approximately 10:30 pm. Sulfur dioxide levels exceeded 10 ppb at a dairy farm in West Virginia for approximately two hours; from 1:44 pm (when monitoring began) until 3:30 pm (there was one 8-minute period where levels dipped below 10 ppb). Sulfur dioxide has been detected in urban, rural, and remote areas. The EPA also monitors sulfur dioxide levels throughout the United States. The EPA reports that the following annual mean concentrations for years 1986 to 1995:

rural areas	about 7 ppb,
suburban areas	about 7 to 10 ppb, and
urban areas	about 7 to 10 ppb (US EPA 2001b)

It should be noted that the levels cited are annual mean concentrations; concentration variations above and below these annual means occur. The levels are reported here to give perspective to the sulfur dioxide levels detected in Cheshire. Exceeding these annual mean concentrations do not mean that harmful effects would occur.

Using a UV fluorescence analyzer, AEP conducted continuous, real-time sulfur dioxide monitoring in and around Cheshire from June 30 through August 17, 2001. Appendix C, Figure 3 displays the peak concentrations detected and the 3-hour average concentrations for each day. Information on the height of sample collection, the duration of the peak sampling, and the reason for sample location were not provided to EPA by AEP. This information would assist in making a more accurate determination of community exposure and public health implications. Sulfur dioxide was found in the ambient air every day that sampling occurred with the highest peak levels detected being 341 ppb at the Addaville School on July 1, 2001. Three-hour average readings of up to 97 ppb were recorded. A summary of sulfur dioxide levels greater than 100 ppb in residential and some non-residential areas is shown in Appendix D, Table 3. The level of 100 ppb is chosen as a reference since it is the lowest sulfur dioxide level where pulmonary effects are seen in asthmatic people.

The Ohio EPA (OEPA) permanent sulfur dioxide monitoring station is located on top of the City Hall building in the center of Cheshire. On July 16, 2001, sulfur dioxide was detected at levels up to 565 ppb for approximately 5 minutes before the levels went out of range (off-scale). The highest one-hour average sulfur dioxide reading for that day was 170 ppb, with the highest three-hour average reading at 61 ppb (US EPA 2001a). Appendix E, Figure 4 shows selected 5-minute peak levels of sulfur dioxide during August and September 2001, at the city hall building. On 8 days over this period, sulfur dioxide levels exceeded 100 ppb, with the highest level detected being 215 ppb.[(1)]

Sulfuric Acid

A contractor for AEP conducted time-weighted air sampling for sulfuric acid, which were analyzed according to NIOSH Method 7903. Sulfuric acid was detected in 79 percent (11 out of 14) of the air samples collected (see Table 4) and ranged from 20 to 200 micrograms of sulfuric acid per cubic meter of air ($\mu g/m^3$). Sample collection times ranged from 29 minutes to slightly more than 7 hours. No information was provided to EPA as to sample location, sample height, what triggered the sampling (e.g., visible plume), or how the sample times were determined.

Table 4. Sulfuric acid air samples results, July 2 and 18, 2001*
AEP Environmental Data

Sulfuric Acid Concentration ($\mu g/m^3$)	Sample Collection Time Minutes (hours)	Sample ID
July 2, 2001		
31.6	381 (6.4)	G-1
200	29 (0.5)	G-4
31.9	525 (8.8)	GAV-05
39.2	215 (3.6)	GAV-08
49.2	370 (6.2)	GAV-10
July 18, 2001		
49.1	440 (7.3)	71201

27.7	418 (7.0)	71202
50	409 (6.8)	71203
59.2	382 (6.4)	71204
20.3	287 (4.8)	71302
20.5	282 (4.7)	71303

* Analysis using NIOSH Method 7903 by the American Electric Power Dolan Chemical Laboratory, Groveport, OH. Date reports 7/2/01 and 7/24/01

The AEP contractor also collected daily air samples for sulfuric acid analysis at various locations in Cheshire from July 13 to August 11. Information about sampling time was not provided to EPA. There were 9 out of 138 sampling periods where sulfuric acid was detected above the detection limit around 35 $\mu g/m^3$. The range of detected levels was 41 to 120 $\mu g/m^3$. A summary of detectable levels are shown in Table 5.

Table 5. Summary of detectable levels of sulfuric acid at various locations around Cheshire collected by AEP, July 13 to August 11, 2001.*

Sulfuric Acid Concentration $\mu g/m^3$	Date	Location
86	July 15	Recreation Avenue
67	July 17	Recreation Drive
42	July 17	McClintic Wildlife Area
120	July 30	Route 7 and Little Kyger Road
41	August 2	Cheshire City Building
46	August 5	Mason County Fair Grounds
35	August 5	Mason County Fair Grounds
57	August 6	River Valley School
54	August 7	Gravel Hill Cemetery

* AEP did not specify the length of time for each sample.

Pathway of Exposure

Residents who live near the Gavin Power Plant are exposed periodically to sulfur dioxide and sulfuric acid via inhalation. Their exposure is episodic, that is, occurs for relatively brief periods as plumes from the power plant migrate from the facility to surrounding areas. The episodic nature of the plumes makes it difficult to determine how frequent and how long residents might be exposed. The limited environmental data available so far, however, shows that residents can be exposed for several minutes to probably several hours as plumes migrate through the surrounding areas. Exposure primarily occurs when residents are outside. However, exposure may occur to some extent indoors if residents keep doors and windows open or when home heating and cooling systems draw outdoor air into the home.

Local meteorological conditions are likely to play an important role in affecting air pollution levels near the Gavin Power Plant. Two factors are likely to be very important: surface wind patterns and stagnation episodes (or inversions). This is evident from reports of a visible plume coming from the power plant on July 16. A possible temperature inversion on that day prevented the plume from rising and a low wind allowed dispersion of the plume into Cheshire. A local resident reported that the plume disappeared after about 90 minutes. Air modeling of emissions from the power plant along with a more detailed evaluation of local meteorological conditions and analysis of geographical and demographic information might provide more insight into the frequency and duration of exposure to sulfur dioxide and sulfuric acid for nearby residents.

Health Evaluation

ATSDR has reviewed the scientific literature for sulfur dioxide and for sulfuric acid and written reports called toxicological profiles that summarize pertinent toxicity data. These reports (that is, ATSDR's Toxicological Profile for Sulfur Dioxide and ATSDR's Toxicological Profile for Sulfur Trioxide and Sulfuric Acid) along with other published scientific reports are the basis for the current evaluation of the public health significance of sulfur dioxide and sulfuric acid pollution in Cheshire.

If sufficient toxicity data are available for inhalation exposure, ATSDR develops inhalation Minimal Risk Levels (MRL) for acute (<1 to 14 days), intermediate (14 to 364 days), and chronic exposure periods (greater than 1 year). Inhalation MRLs are contaminant concentrations in air below which non-cancerous harmful effects are unlikely. Exceeding an MRL does not mean that harmful effects will occur but rather than a more thorough toxicological evaluation is necessary. In conducting a more thorough toxicological evaluation of the data for this site, ATSDR compared the ambient levels of sulfur dioxide and sulfuric acid detected in and around Cheshire Village to results from human and animal studies to determine if harmful effects might be possible for the residents.

Sulfur Dioxide

Pulmonary effects:

The most sensitive people to sulfur dioxide exposure are individuals with asthma, particularly children. The effects of sulfur dioxide exposure on lung function in asthmatics are summarized in Table 6. A study by Sheppard et al. have shown that people with mild asthma exposed to 100 ppb sulfur dioxide for 10 minutes experienced an increase in airway resistance and broncho constriction during moderate exercise (ATSDR 1998a, Sheppard 1981). This increase in airway resistance and bronchoconstriction is more pronounced in people exposed to 250 ppb and 500 ppb. At 500 ppb, the increased airway resistance and bronchoconstriction are associated with wheezing and difficulty in breathing in some people with asthma. Similarly, Balmes et al. have shown an increase in airway resistance in people with asthma when exposed to 500 ppb for 3 minutes (ATSDR 1998a, Balmes 1987). The resulting bronchoconstriction also resulted in wheezing, chest tightness, and shortness of breath. Numerous other human studies support the findings of these studies in causing an increase in airway resistance and bronchoconstriction in asthmatic people exposed to several hundred ppb sulfur dioxide (ATSDR 1998a). Besides asthmatics, another sensitive group is elderly adults with preexisting respiratory or cardiovascular disease or chronic lung disease, such as bronchitis or emphysema (WHO 1979, US EPA 2001a).

Non-asthmatic people can also experience pulmonary effects when exposed to sulfur dioxide; however, a higher level of exposure to sulfur dioxide is required. Islam et al. report that non-asthmatic people exposed to 600 to 800 ppb sulfur dioxide for 5 minutes, *using a mouthpiece apparatus*, can produce an increase in airway resistance (Islam et al. 1992). It should be noted that the 600 ppb exposure group in the Islam study is an effect level; the authors did not identify a no effect level in their study. Uncertainty exists in applying this study to the non-asthmatic public because the authors used a mouthpiece to measure the delivered dose of sulfur dioxide. Using a mouthpiece might increase the amount of sulfur dioxide that enters the lungs because trapping of sulfur dioxide in the nasal passages is avoided. The levels used in this study might be more applicable to exercising, non-asthmatic people since exercise increases breathing through the mouth rather than the nose. That levels of 600 to 800 ppb sulfur dioxide can cause an effect in non-asthmatics, however, is supported by other research. Lawther et al. showed that a similar response occurred at 1,000 ppb sulfur dioxide (Lawther et al. 1975). Also at 1,000 ppb, people can experience an increase in heart rate and breathing rate (Amdur et al. 1953, ATSDR 1998a). Therefore, somewhere between 600 ppb and 1,000 ppb sulfur dioxide, non-asthmatic people might begin to experience pulmonary effects. The 565 ppb sulfur dioxide detected at the city hall on July 16 is a cause for concern because the level is close to the levels that can affect asthmatic and possibly non-asthmatic people. It should be noted that the instrument measuring the sulfur dioxide went off the scale and so sulfur dioxide levels were likely higher than 565 ppb.

People's activity level and the weather conditions are also a factor in whether or not people will experience effects from exposure to sulfur dioxide. When people are at rest and breathing normally, sulfur dioxide is absorbed in the moist environment of the nasal passages and less sulfur dioxide reaches the bronchioles and lower portions of the lungs. Therefore, people at rest can be exposed to higher levels of sulfur dioxide before experiencing effects on the lung compared to people who are exercising. During exercise or increased activity, however, people breathe faster and are more likely to breathe through their mouth; therefore, more sulfur dioxide reaches the bronchioles and lower levels of the lung. These factors result in more sulfur dioxide reaching the lungs thus causing an increase in airway resistance and bronchoconstriction. The weather also becomes a factor, because more sulfur dioxide will reach the bronchioles in cold, dry (low humidity) atmospheres, thus increasing the likelihood of increased airway resistance and bronchoconstriction (ATSDR 1998a, Bethel et al. 1984, Sheppard et al., 1984, Linn et al., 1985).

Table 6: Summary of Studies on Pulmonary Effects of Sulfur Dioxide Exposure in Asthmatic Individuals

$[SO_2]$	Duration	Exposure Conditions	Effect Endpoint	Reference
600 ppb	5 min	chamber exposure, heavy exercise	significantly increased airway resistance	Linn, 1983
500 ppb	10 min	mouthpiece apparatus, exercise	increased airway resistance in 7/7 subjects	Sheppard, 1981
500 ppb	3-5 min	mouthpiece apparatus hyperventilation	increased airway resistance	Balmes, 1987
400 ppb	5 min	chamber exposure, heavy exercise	moderately increased airway resistance	Linn, 1983
250 ppb (lowest dose tested)	40 min (10 min exercise)	chamber exposure, exercise	slight, but statistically significant decrease in air flow rate	Schachter, 1984
250 ppb (only dose tested)	5 min	chamber exposure, moderate exercise	increased airway resistance	Bethel, 1985
250 ppb	3 min	mouthpiece apparatus	increased airway resistance	Myers, 1986a, 1986b
250 ppb (lowest dose tested)	10 min	chamber exposure, exercise	reanalysis of Roger et al, 1985 data indicates airway effects in some subjects	Hortsman, 1986
250 ppb	10 min	mouthpiece apparatus, exercise	increased airway resistance in 3/7 subjects	Sheppard, 1981
250 ppb (lowest	10-70 min	chamber exposure, exercise	no increase in airway resistance	Roger, 1985

dose tested)				
200 ppb (lowest dose tested)	5 min	chamber exposure, heavy exercise	no increase in airway resistance	Linn, 1983; 1987
100 ppb (only dose tested)	40 min (10 min exercise)	mouthpiece apparatus, moderate exercise	no increase in airway resistance from SO_2 alone; increase observed in combination with 68 $\mu g/m^3$ sulfuric acid	Koenig, 1989
100 ppb	3 min	mouthpiece apparatus, hyperventilation	increased airway resistance	Sheppard, 1981
100 ppb	3 min	mouthpiece apparatus, hyperventilation; cold, dry air	increased airway resistance	Sheppard, 1984

Assessment of impact for residents of Cheshire Village:

The level of sulfur dioxide detected in and around Cheshire Village frequently exceeds ATSDR's acute, inhalation Minimal Risk Level (MRL) of 10 ppb. Exceeding an acute MRL does not mean that harmful effects might occur but rather that further toxicological evaluation is warranted. ATSDR has not developed inhalation MRLs for intermediate and chronic exposure periods because insufficient data are available to develop reliable health guidelines.

In and around Cheshire Village, air monitoring at several locations has exceeded sulfur dioxide levels discussed previously that may have caused adverse pulmonary effects in some people if they were to be caught in the plume. The highest level reported to ATSDR was found on the roof of the City Hall, which showed sulfur dioxide levels exceeding 565 ppb for 5 minutes with a 3-hour average of 61 ppb. At the River Valley High School, the highest sulfur dioxide level was 120 ppb for several minutes.

The pattern of sulfur dioxide levels at the high school over a 21-hour period showed initial spikes of sulfur dioxide for the first 6 hours followed by very low levels of sulfur dioxide for the remaining period. Before and after the peak level of 120 ppb, sulfur dioxide levels were detected between 40 and 70 ppb for about 2 hours before falling to 20 ppb. In addition, the power plant contractor sampled outdoor air in and around Cheshire Village and reported 10 days with maximum levels above 100 ppb with the highest level being 341 ppb at the Addaville school (see Appendix C, Figure 3). Air samples for sulfur dioxide were also taken further away at a nearby dairy farm in West Virginia. Sulfur dioxide levels at the farm showed a similar pattern of several spikes during a 2-hour period followed by very low levels for the next 3 hours. The highest sulfur dioxide levels at the farm were between 25 and 90 ppb.

Periodically, the ambient air levels of sulfur dioxide are within the range of levels that have been shown under laboratory conditions to cause pulmonary changes considered to be adverse. People with asthma appear to be especially sensitive. At the highest levels of sulfur dioxide reported to ATSDR (that is, 565 ppb for 5 minutes at City Hall), both asthmatic and possibly non-asthmatic people might experience an increase in airway resistance and bronchoconstriction, particularly during exercise or increased activity. The effects of this exposure are likely to be more pronounced in people with asthma because of their increased sensitivity. The level of 565 ppb might cause wheezing, tightness in the chest, and difficulty in breathing for some people if they were to be caught in this plume. In addition, several locations around Cheshire Village have sulfur dioxide levels that exceed 100 ppb (see Appendix C, Figure 3; Appendix D, Table 3; and Appendix E, Figure 4). These levels might cause an increase in airway resistance and bronchoconstriction in some asthmatic people while exercising or during periods of increased activity.

Sulfuric Acid

Sulfuric acid levels on July 2 and July 18 near the Gavin Power Plant ranged from 20 to 200 micrograms per cubic meter ($\mu g/m^3$) with average levels being 30 to 50 $\mu g/m^3$ (see Table 4). Most of these levels are averaged over more than 4 to 6 hours; therefore, it is difficult to determine the actual short-term maximum values, and the duration of those maximum levels within the sampling time period. It should be noted, however, that the shortest sample period (29 minutes) had the highest sulfuric acid levels (200 $\mu g/m^3$). Descriptions of the specific sample locations, weather conditions, date and time of day of sample collection, and if sampling occurred in a visible plume were not available to ATSDR. This information would assist in determining if the current sample results represent typical, worst case, or best case concentrations.

Another set of sulfuric acid samples from July 13 to August 11 by AEP showed elevated levels of sulfuric acid at various locations in and around Cheshire (see Table 5). The highest level detected was 120 $\mu g/m^3$ sulfuric acid at Route 7 and Little Kyger Road. Of the 138 samples taken in and around Cheshire, 9 samples exceeded the detection limits for sulfuric acid, which varied from about 30 to 40 $\mu g/m^3$. Finding so many non-detectable levels of sulfuric acid shows the episodic nature of sulfuric acid levels in and around Cheshire Village.

Not knowing the sampling time limits the ability of using these data to draw firm conclusions about the possibility of harmful effects. However, the environmental data provided by the EPA do give sampling times and are what ATSDR is using to determine the public health significance of sulfuric acid levels in air.

ATSDR has not developed an acute MRL for sulfuric acid; therefore, we compared the air levels measured at the site to levels in human and animal studies that cause harmful effects. Many human and animal studies show that low levels of sulfuric acid can damage the lung. As with sulfur dioxide, people with asthma are particularly sensitive. Hanley et al. reported a temporary decrease in forced vital capacity and forced expiratory volume for exercising asthmatic children (age 12 to 19) exposed to 70 micrograms per cubic meter ($\mu g/m^3$) sulfuric acid for 40 to 45 minutes (Hanley 1992). Several studies (reviewed in ATSDR 1998b) have shown that people exposed to 100 $\mu g/m^3$ for 1 to 2 hours experienced the following changes to the lung:

- an increase in respiratory resistance
- a decrease in maximum air flow at 50% and 75% vital capacity
- a slight decrease in forced expiratory volume
- decreased pH of alveolar macrophage
- decreased phagocytic activity of macrophages
- decreased production of superoxide anion and tumor necrosis factor activity
- a reduced rate of bronchial mucociliary clearance of 5.2 micrometer particles
- an increased responsiveness of bronchial rings to acetylcholine and histamine

At somewhat higher levels of 350 to 450 $\mu g/m^3$, other studies have shown the following pulmonary effects:

- a decrease in specific airway conductance at rest,
- a reduction in forced expiratory volume
- a reduction in maximum expiratory flow rates at 60% total lung capacity
- an increase in respiration rate
- a decrease in maximum flow rate

People with asthma have the greatest sensitivity to sulfuric acid and have experienced effects when sulfuric acid levels are as low as 70 $\mu g/m^3$. Non-asthmatic people have experienced pulmonary effects starting at levels of 100 $\mu g/m^3$ but more typically at levels of 350 $\mu g/m^3$. As mentioned previously, the highest average level reported for sulfuric acid is 200 $\mu g/m^3$, although the location of this sample was not reported to EPA. This level exceeds or approaches the levels that are known to cause harmful effects mentioned previously. Most of the sulfuric acid levels are reported to be around 30 to 50 $\mu g/m^3$; however, these levels are averaged over a 4 to 6 hour period so it seems reasonable to assume that people might be exposed for several hours at sulfuric acid levels that are higher than the average levels reported (see Table 4). It is also uncertain if these averages represent a worst case scenario.

Combined Exposure to Sulfur Dioxide, Sulfuric Acid, and Other Air Contaminants

The combined exposure to sulfur dioxide and sulfuric acid may potentiate the toxic effects that might result from exposure to either chemical alone. Concurrent exposure to sulfuric acid and sulfur dioxide will increase the toxicity of sulfuric acid. Koenig et al. did not observe effects in people exposed to 100 ppb sulfur dioxide but did see an increase in respiratory resistance when people were exposed to 100 ppb sulfur dioxide and 68 $\mu g/m^3$ sulfuric acid (Koenig et al. 1989). This study showed that exposure to sulfuric acid levels that normally do not cause respiratory resistance could lead to a response when sulfur dioxide is a co-contaminant, which could be the case for ambient air near the Gavin Power Plant. This point is highlighted by ambient air data from Cheshire on July 15. On July 15, AEP measured sulfur dioxide levels at 130 ppb on Recreation Avenue and Route 554 (see Appendix D, Table 3) and sulfuric acid levels at 86 $\mu g/m^3$ on Recreation Avenue. Further information is required to determine if the sampling locations are the same or close to each other.

The absorption of sulfuric acid to metal oxides (particulates) may increase toxicity of sulfuric acid because it allows more sulfuric acid to penetrate into the alveolar regions of the lung. Specifically, Amdur et al. showed that sulfuric acid bound to the surface of zinc oxide aerosol was more potent in decreasing the diffusing capacity of carbon monoxide in guinea pig alveoli than sulfuric acid alone. A decrease in the diffusion capacity indicates an impairment of lung's ability to oxygenate blood. This effect was not seen at 20 $\mu g/m^3$, but was seen at 30 $\mu g/m^3$ with a significant reduction at 60 $\mu g/m^3$ (Amdur 1989b). This effect becomes a concern for the Cheshire Village situation because power plants that burn coal are known to produce sulfuric acid that is bound to the surface layer of metal oxides (Amdur 1989b, Amdur 1986). In addition, several studies have shown that the presence of ozone potentiates the effects of sulfuric acid exposure in rats exposed to 40 $\mu g/m^3$ sulfuric acid (Amdur 1989a, Kimmel et al. 1997). In addition to these studies, a transient reduction in lung capacity (forced vital capacity or FVC) and forced expiratory volume in 0.75 seconds ($FEV_{0.75}$)) occurred in children exposed to sulfur dioxide levels greater than 170 ppb and total suspended particulate levels of 0.27 milligrams per cubic meter (mg/m^3). Children's lung capacity returned to normal 2 to 3 weeks after exposure.

Susceptibility of Children and Other Groups

Numerous studies show that asthmatic people are more sensitive to sulfur dioxide and sulfuric acid than non-asthmatic people (ATSDR 1998a, 1998b). In addition, asthmatic children tend be more sensitive to sulfuric acid than asthmatic seniors. This conclusion is based on a study conducted by Koenig et al. who showed that exercising asthmatic children experienced increased respiratory resistance, decreased maximum flow at 50% and 75% of vital capacity, and decreased forced expiratory volume when exposed to 100

$\mu g/m^3$ sulfuric acid, while asthmatic seniors did not (Koenig et al. 1985, Koenig et al. 1993).

The increased susceptibility in asthmatic people might be explained by the lower pH that exists in mucous lining the airways compared to non-asthmatic people (5.3 to 7.6 pH vs 7.4 to 8.2 pH). Having a lower pH reduces the ability of the mucus mass to neutralize the hydrogen ions produced from sulfuric acid exposure, which results in changes in the surrounding tissue. Lowering the pH of the mucus mass might also reduce mucociliary clearance, which may mean that smokers or people who breathe second hand smoke are more sensitive to sulfuric acid. Infants might also be more susceptible to sulfuric acid in air due to incomplete development of the mucosa and mucous during the first few months after birth (ATSDR 1998b, Holma 1985).

Averaging Times for Air Sampling Data

One of the problems in evaluating the impact of exposure to air contaminants is the sample collection time and whether or not the average concentration was presented as the result. Twenty-four hour samples and annual averages are used to determine if EPA's primary ambient air quality standard for sulfur dioxide has been exceeded, and the 3-hour average serves as a secondary standard. These ambient air quality standards were developed to protect most people but may not be protective of all people in a community.

However, a review of toxicity data for exposures lasting just a few minutes clearly demonstrates that airway resistance, bronchoconstriction, and other pulmonary responses can occur (ATSDR 1998a, 1998b). Therefore, it is more appropriate to average the air concentrations over periods that are relevant for the onset of adverse pulmonary effects. The use of much longer averaging times (for example 3 and 24 hours) could mask actual health impacts to exposed individuals. Therefore, data should be collected and reported in a time frame that reflects the time course for the onset of acute symptoms in people. These time frames are 5 to 10 minutes for sulfur dioxide and 1 to 2 hours for sulfuric acid.

Uncertainty in Health Evaluation

Uncertainty exists in deciding whether or not people might experience harmful effects from sulfur dioxide and sulfuric acid emissions from the Gavin Power Plant. Some uncertainties tend to overestimate the risk of harmful effects while other uncertainties tend to underestimate the risk. The uncertainties in this evaluation follow.

1. Experimental studies indicate that the increased pulmonary resistance in response to short term sulfur dioxide and sulfuric acid exposure is a response that can be reversed within several hours after the exposure has stopped. However, the health impact of repeated short-term exposures to sulfur dioxide and sulfuric acid that are at or near levels that will cause increased pulmonary resistance cannot be evaluated

using existing human studies. Not being able to evaluate the effect of repeated exposure to sulfur dioxide and sulfuric acid may *underestimate* the risk when the evaluation is based on a 1-time single exposure.

2. Inhalation toxicity studies for sulfur dioxide and sulfuric acid referenced in this report used aerosols of either sulfur dioxide or sulfuric acid. However, at this site, these contaminants are likely to be associated with metal oxide particulates in the power plant emissions, which are known to enhance the toxicity of sulfur dioxide and sulfuric acid by depositing the chemicals deeper in the lungs. In addition, the atmospheric conversion to acid sulfates, ammonium sulfate, and other oxidation products, may further contribute to the toxicity of the mixture. Since the experimental studies cited in this assessment were not designed to evaluate the impact of the combined effect of sulfur dioxide, sulfuric acid, particulates, and other contaminants, the use of dose-response information from these studies could *underestimate* the health impact of actual environmental exposures.

3. The use of mouthpiece apparatus for inhalation studies does not reflect normal breathing patterns, which tend to be more nasal under resting conditions and oral-nasal during exercise. Since absorption of contaminants in the nasal passages reduces the dose that reaches the airways and lungs, the dose-response predications from these studies may tend to *overestimate* the health impact of actual environmental exposures.

4. Although there has been a significant amount of air sampling that has occurred over the past several months, the locations and height for some of the sampling points may not accurately reflect actual breathing zone. The concern is the concentrations closer to the ground level (that is, breathing level) may be greater or lower than those detected by these samples. Therefore, the evaluation of data from unknown sampling heights may *overestimate or underestimate* the risk of harmful effects.

5. At times, the ability to interpret outdoor air measurements was hampered because the time frame for collecting air samples was different from the time frame for the most appropriate toxicological data. To determine the toxicity of sulfur dioxide, air samples are needed for very short periods (for instance 5 to 10 minutes) throughout the day. For sulfuric acid, air samples are needed for approximately a 1 hour interval. Therefore, when air monitoring data averages air concentrations over longer sampling periods, the levels may underestimate critical exposure concentrations and thus *underestimate* the risk of harmful effects.

6. There is insufficient information to draw definite conclusions regarding the temporal association between the peak concentrations of sulfur dioxide and sulfuric acid, and the specific time of onset of respiratory symptoms reported in the Cheshire Village area. However, EPA has received a message from a family in Cheshire stating that their asthmatic daughter developed severe breathing problems on

October 9th at 2:15 a.m. and the family took her to the emergency room for treatment. Evaluation of the sulfur dioxide monitoring data in at Cheshire's city hall for that time period reveals that outdoor air levels were low for several days before October 9, peaked mid-day on October 9th, and remained elevated for 3 days, with maximum concentrations of 175 ppb (see Appendix E, Figure 4).

Demographics

Based on the 1990 census, about 250 people live in Cheshire with 24 preschool children and 37 elderly. In addition, several schools are nearby, which include students from outlying areas. The schools include the River Valley High School, the Kyger Creek Middle School, the Addaville Elementary School, and the Guiding Hands School. Appendix A shows additional demographics for Cheshire.

CONCLUSIONS

Based on a review of environmental data provided by EPA, ATSDR concludes that episodic elevations of sulfur dioxide and sulfuric acid levels in and around Cheshire pose a public health hazard to some residents, particularly residents with asthma. While levels appear to not be life-threatening, pollutant levels have been high enough to cause bronchoconstriction and increased airway resistance. At least on one occasion at Cheshire's city hall, levels of sulfur dioxide were high enough to cause wheezing, tightness of the chest, and difficulty breathing in some people. Some of the sulfuric acid levels were also high enough to cause mild, adverse effects on the lungs.

Not everyone will experience adverse effects when exposed to sulfur dioxide and sulfuric acid at the levels detected in the environmental samples. ATSDR is concerned, however, that some people, particularly children and asthmatics, might be more sensitive and might experience breathing problems if sulfur dioxide and sulfuric acid levels remain elevated.

Uncertainty exists in deciding whether or not people might experience harmful effects from sulfur dioxide and sulfuric acid emissions from the Gavin Power Plant. Uncertainties that may *underestimate* the risk include: (a) repeated exposure to periodically elevated levels of sulfur dioxide and sulfuric acid, (b) effects contaminants binding to other pollutants, (c) nasal deposition versus lung deposition of pollutants, and (d) the long sample averaging times. Uncertainty that may *overestimate* the risk is: nasal deposition versus lung deposition of pollutants. The height of air sampling in relationship to breathing height may either *underestimate or overestimate* the risk.

Other factors also affect whether or not residents in Cheshire might be exposed to pollutants from the Gavin Power Plant and might experience harmful effects. These factors include meteorological conditions necessary to allow a plume to migrate from the plant to areas where people live or work.

RECOMMENDATIONS

1. Reduce peak levels of sulfur dioxide and sulfuric acid in the community's ambient air as soon as possible to avoid harmful effects from acute exposures.

2. Continue to collect air samples in and around Cheshire and measure for priority pollutants, including sulfur dioxide and sulfuric acid. Work with ATSDR staff members to develop a sampling plan that will allow public health officials to determine if residents' health is being protected.

3. Consider conducting air modeling to determine areas that might be impacted by pollutant discharges from the Gavin Power Plant.

PREPARERS OF THE REPORT

David M. Mellard, Ph.D.
Toxicologist
Division of Health Assessment and Consultation
ATSDR, Atlanta

Lynn C. Wilder, CIH
Environmental Health Scientist
Division of Health Assessment and Consultation
ATSDR, Atlanta

Mark Johnson, Ph.D., DABT
ATSDR Senior Regional Representative
Office of Regional Operations
ATSDR, Chicago

Reviewers:

Allan Susten, Ph.D., DABT
Director for Science
Division of Health Assessment and Consultation
ATSDR, Atlanta

Susan Moore, Chief
Health Consultation Section

Division of Health Assessment and Consultation
ATSDR, Atlanta

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APPENDIX A: MAP OF GAVIN POWER PLANT AND CHESHIRE

APPENDIX B: SULFUR DIOXIDE AMBIENT AIR MONITORING JULY 2 AND 3, 2001 EPA ENVIRONMENTAL DATA

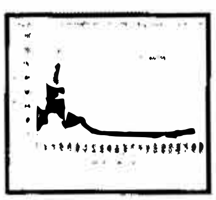

Figure 1. River Valley High School

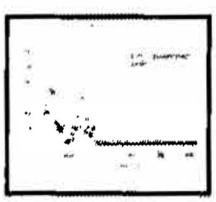

Figure 2. Dairy Farm in West Virginia

APPENDIX C: SULFUR DIOXIDE AMBIENT AIR MONITORING UNSPECIFIED LOCATIONS JULY 2001 AEP ENVIRONMENTAL DATA

Figure 3. Sulfur Dioxide Ambient Air Monitoring, Unspecified Locations, July 2001

APPENDIX D: TABLE 3. SUMMARY OF PEAK SULFUR DIOXIDE LEVELS GREATER THAN 100 PPB

Table 3. Summary of peak sulfur dioxide levels greater than 100 ppb.
Based on AEP environmental data collected June 30 to August, 2001 using a mobile unit

Date	Peak sulfur dioxide level in ppb	Location
July 2	104	Addison Park
	341	Addaville School
	268	Pike Boltville
July 15	130	Rt 554 and Recreation Avenue
	112	Univ Marshall Rt 15 WV
	119	Pt Pleasant Middle School
	172	Little Kyger and Oliver Road
July 16	174	Story Run at Oil Tanks
	137	554 and Recreation Drive
	101	AEP Dock Lakin Rd
	188	Main Guard Shack
July 17	113	Potter Creek Road and 11 WV
July 19	189	Gavin Plant, Main Office
July 21	145	Gravel Hill Cemetery
	128	Plant Near Flyash Transfer

	160	Plant SW side of Unit 1
July 22	163	Plant Near Unit 2 Flyash Transfer
	185	Plant overflow pond & TUFS Tank Ave.
	129	Plant Thickner ave & overflow pond
	255	Storys Run Road, Gravel Roll-off
	121	Cheshire Village Building, Playground
	105	Flyash transfer Unit 2 West side
July 23	113	Plant West of Unit 2 Flyash Transfer
	104	Storys Run Road, E. of 4-way Intersection
	109	Storys Run Road, Eastbound
July 24	131	Plant Between Unit 2 and Unit 2 Flyash Transfer
	108	Storys Run Road, Gravel Pull-off
July 25	189	Plant between Unit 2 & Unit 2 flyash transfer bldg
	230	Plant between Unit 1 and Unit 2
	161	Plant between Unit 1 and Unit 2
	130	Plant between Unit 1 and Unit 2
	162	Cheshire Ball Field
	227	Cheshire Ball Field
	147	Cheshire Ball Field
	133	Plant between Unit 2 and Flyash Bldg
July 26	315	Plant between Unit 1 and Unit 2
	109	AEP Landfill Offices
	122	AEP Landfill Offices
	114	AEP Landfill Offices
	157	Main Guard Shack
July 27	110	Addison Pike & Reese Hollow
	108	Bunce rd & Keeler Rd
	146	Keeler Rd & Bolaville Pike

July 30	180	Rte 7 Rest area
	206	Rte 7 Rest area
	175	Rte 7 Rest area
	210	Rte 7 & Little Kyger Creek
	161	Gravel Hill Rd @ RR
	171	Gravel Hill Rd @ RR
	164	Gravel Hill Rd @ RR
	139	Gravel Hill Rd @ RR
	245	Addaville School
	187	Addison Freewill Baptist Church
	202	Addison Freewill Baptist Church
	176	Addison Freewill Baptist Church
	175	Addison Freewill Baptist Church
	223	Rte 7 & Little Kyger Rd
	144	Rte 7 & Little Kyger Rd
	130	Marathon N. Addison
	158	Marathon N. Addison
	143	Marathon N. Addison
	192	Rest Area
	175	Rest Area
	198	Rest Area
	160	Rest Area
	137	Addison Freewill Baptist Church
	128	Addison Freewill Baptist Church
	122	Addison Freewill Baptist Church
	121	Addison Freewill Baptist Church
	115	Addison Freewill Baptist Church
August 1	115	Gravel Hill Rd & RR Overpass
	102	Gravel Hill Rd & RR Overpass

August 3	113	Unit 2- cooling tower tank 1 bldg
August 18	109	Plant between Unit 2 and Unit 2 Flyash Trans

Source: AEP Environmental Data
June 30 to August, 2001

APPENDIX E: SULFUR DIOXIDE AMBIENT AIR MONITORING TOP OF CHESHIRE CITY HALL AUGUST AND SEPTEMBER 2001 OHIO EPA ENVIRONMENTAL DATA

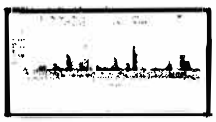

Figure 4. Sulfur Dioxide Ambient Air Monitoring, Top of Cheshire City Hall, August and September 2001

1. Because the data are so extensive, ATSDR selected portions of 5-minute peak data to convey the episodic nature of sulfur dioxide levels with some periods having low levels of sulfur dioxide compared to brief periods of high levels.

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